Thermal Transport and Fracture Behavior of Sintered Fuel Pellets: Experimental Validation of NEAMS Tool MARMOT

PI: Jie Lian, Rensselaer Polytechnic Institute

Collaborators: Michael Tonks – Pennsylvania State Univ.
Pritam Chakraborty – Idaho National Lab
Krzysztof Gofryk – Idaho National Lab

Program: [NEAMS]

ABSTRACT:

The PIs propose an integrated research program synergizing experimental and computational efforts to obtain critical experimental data for validation of physics-based MARMOT thermal transport and fuel fracture models. The key components of the project include: (1) sintering UO_2 samples with well controlled microstructures (grain size, pore, fission bubble, porosity and pore distribution either in intra- or inter-granular pores); (2) thermal conductivity measurements of well-characterized polycrystalline samples; (3) indentation testing of sintered UO_2 with various grain size, porosity and stoichiometry to obtain fracture and crack propagation mechanisms (inter or intra-granular fracture); and (4) validation and uncertainty quantification of the MARMOT thermal transport and fracture models. By performing extensive thermal transport and fracture experiments on sintered UO_2 with well-controlled microstructures, the impact of microstructure on thermo-mechanical properties of sintered UO_2 and mechanistic understanding will be achieved. The high quality experimental data will directly benchmark the MARMOT code by evaluating the fidelity of physical-based thermal transport and fracture models.

The proposed work is well aligned with the guideline of "NEAMS software verification and validation plan for the MARMOT software" issued by DOE-NE, directly addressing the work scope of NEAMS by supporting its missions of creating modern computer fuel performance codes and methods that give a state-of-art predictive modeling capability. The success of the proposed project will effectively validate the thermal transport and fracture-related models within the framework of MARMOT, providing a benchmarked capability particularly for more accurate prediction of fuel properties and performance. The knowledge and approach developed in designing target experiments with well controlled microstructure to obtain critical data needed for NEAMS validation can be well extended to multiple fuel systems other than conventional LWR oxide fuels. Future experiments on accident tolerant fuels such as silicide or nitride fuels will be planned in the next phase of the project.

This project is built upon our extensive expertise and complimentary capabilities of the PIs at Rensselaer Polytechnic Institute, Pennsylvania State University and partners at Idaho National Laboratory. The close collaboration with the NEAMS team at PSU and INL will ensure well aligned experiments fulfilling the critical needs of the NAEMS program in developing modern computer fuel performance codes and methods that give a state-of-art predictive capability.